Factors affecting Science Identity among Secondary School Students

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Abstract: *This study is the foremost of its kind, which tries to understand science identity and the factors contributing towards the formulation of this identity in an Indian context. Science identity is a pertinent construct which ensures the long-term persistence of students in the field of science, which often remains unexplored through use of conventional variables such as achievement, interest. A descriptive survey was used to assess science identity, wherein around 6% showed higher identification with science while most others belonged to average category. In order to determine factors affecting development of science identity, significant correlations were found with teacher expectations and self-beliefs(r = .703), perception of science and scientists (r = .542), Parental attitude towards science (r = .499), peer attitude towards science (r = .430), Perception of Role models (r = .080) and STE aspirations (r = .477). Regression analysis was also done, for which the given variables contributed to 78.9% variance in science identity. No significant differences were reported between urban and rural student's science identity. This study preludes to the necessity of rigorous efforts on part of teachers and parents, as they are pertinent contributors towards science identity establishment among students.*

Key Words: *Science identity, Perception of science and scientists, Teacher expectations and self-beliefs, STE aspirations, Peer attitude towards science, Parental attitude towards science, Perception of role models*

1. INTRODUCTION:

Science identity as a construct is difficult to be crystallized into stringent parameters, this comes from the fact that a large number of predetermined and interrelated factors help define the function of it. Various researchers have tried to contribute to understanding science identity such as Carlone, 2007 proposed a grounded model of science identity that provides a theoretical and methodological basis for research. This model captures the essence of science identity in terms of three interrelated dimensions of competence, performance, and recognition. Competence referred to the knowledge and understanding of the science content, Performance refers to the social performance of relevant scientific practices and recognition is recognizing oneself or by others as a science person. All of these dimensions overlap and can vary in their degree and proportion from a person to person. They have also defined science identity as something which is not just based on abilities and aspirations related to science but also what comes out of constraints and resources available. So as to say, a person with strong science identity is competent, has a meaningful understanding and is motivated to learn science with the required skill set for competence.

Carlone's model also derives upon from Gee's theory of identity (1999) which states that one can't be regarded a certain person unless their credibility has been recognized by others i.e. science identity is socially constructed (Lewis, 2003).Gee's theory has categorized four different factors which are responsible for the formulation of science identity. Firstly is related to genetics or hereditary, other are roles which determine societal position, then is recognition by other and lastly is the perspective of likeminded others. Identity changes can also result due to complex interactions between all the four perspectives. Bricker and Bell (2014) have also regarded identity as a reflexive ongoing process which is influenced by experiences one gain from past and present environment.

Flowers and Banda (2016) also studied science identity through sources of self-efficacy wherein they have deliberated on different components of science identity. These multifarious components are divided into three categories, 1) belief of capability, performance and self-efficacy, 2) Student recognition, competence and academic perception of self, 3) Career interest and engagement with the scientific community, recognition. They have further proposed that development of higher self-efficacy implicitly lead to higher participation in the STEM, as higher self-efficacy corresponds to longer persistence.

Deriving upon from this theoretical framework a large number of studies have conducted to study underrepresentation in STEM-related careers based on gender, ethnicity (Brown, Reveles & Kelly, 2005; Banda, 2012; Flowers, 2011;Tonso, 2007).Buxton and Lee, 2010 have also reported marginalization of science students based on socioeconomic status, gender, ethnicity and linguistic differences.

2. CONCEPTUAL FRAMEWORK:

Building upon from Gee's theory and Carlone's grounded model of scienceidentity, a conceptual framework for the current research has been synthesized. Science identity has been defined by Chapman and Feldman (2017) as being recognized as a certain person in a given context. Similarly,Brickhouse and Potter (2001), relate to science identity as a process by which students recognize who they are, what they believe they are capable of, what career interest they have and how they engage within the scientific community. In more psychological terms (Shanahan, 2009) has described it as who one is and who one wants to be in the context of science, it is based on every individual's ability to shape the world around them. For the purpose of this study Carlone and Johnson (2007) definition of science, identity will be used which complies that students science identities are constructed as a recognition of themselves and by significant other as scientists, which are reliant on their ability to do and know science.

Socioeconomic status, gender, ethnicity, and linguistic differences are also certain factors that have propelled towards marginalization of students in the science classroom (Buxton and Lee, 2010).The counter effects of such disparity are that students facing marginalization have more affinity to be placed in science classes that emphasize memorization, rote learning, and lower levels of learning experiences leading towards lower academic expectations (Oakes, 2000). The absence of adequate equipment for experimentation and lack of inquiry-based activities is also found under aforementioned circumstances (Oakes 1990).This further accentuates disengagement among students (Basu & Barton 2007), as they regard to see science as irrelevant and unexciting (Seiler, 2001).

The role of recognition by oneself and others has also been examined as student's perceptions about who can do science (Rahm, 2007) and their perceptions of scientists (Aschbacher, Li &Roth 2010). It has been well documented that students 'stereotypical perceptions of scientists as a wild-haired White male wearing a lab coat and working indoors in a laboratory (Finson, 2002) have contributed to their marginalization in science (Brick house and Potter 2001).The extent of perceptivity can also mediate science aspirations wherein a student can imagine himself in a future career given that favorable resources are available (Aschbacher et al., 2010; Boe, Henriksen, Lyons, & Schreiner, 2011).

Other significant contributions in relation to enhancement of science identity and sense of learners by participation in out of school activities have been reported by (Riedinger & Taylor, 2016).They have examined the purpose of out-of-school time (OST) programs and found that these programs provide the youth access to resources/tools and scientific practices unavailable in classrooms (Luehmann, 2009).Role models also act as catalysts in academic development, Palmer and Gasman (2008) have found them to be significant as they provide encouragement and a positive self-confidence (Russell and Atwater, 2005).Russell and Atwater's (2005) and Brown's (2002) have produced findings which embarks on stern factors such as pre-college science experiences, family support, teacher encouragement, intrinsic motivation in the promotion of science among undergraduate students.

The central idea of this research is to first study the representation of science identities among secondary school students of India. Studies related to achievement and interest donot present the true picture of why certain students stay in and others opt out of science. Therefore, here is the need to explore the fluidity of science identity which targets not just short-term interest but long-term sustenance in science, which is also the second objective of the study. Also, nuanced consideration of factors responsible for nurturing science identity will be explicitly detailed and discussed. The current study implies to understand structural factors (locale) along with it a range of determinants which include the perception of science and scientists, teacher expectation and self-belief, parents attitude towards science, peer attitude, perception of role models and STE (Science, Technology and engineering) aspirations in constructing science identity of adolescents.

3. RESEARCH QUESTIONS:

The research questions for this study were as follow:

- How well do students identify themselves with science?
- What is the relationship between student's science identity with their perception of science and scientists, teacher expectations and self-beliefs, STE aspirations, Parental attitude towards science, Peer attitude towards science and perception of role models in science?
- To understand the contribution of aforementioned variables in the prediction of science identity?

4. METHODOLOGY:

PARTICIPANTS AND DATA COLLECTION

The study is a descriptive survey-based study which was conducted in the state of Haryana, India. Since the study aimed to identify the differences between rural and urban students, therefore a sample of 137 students was taken from urban and a rural school purposively. For the rural sample, the school taken was a senior secondary school located in rural village of Haryana. The sample taken comprised of 64% girls and 36% boys. Urban sample was taken from a school located in the urban district of Haryana state and comprised of 47%girls and 53% boys. A diverse sample including students from diverse socioeconomic backgrounds was included in the study.

In order to collect data, a comprehensive questionnaire based on "is science me" (Aschbacher, Li & Roth, 2010) was used.Student's opinions were obtained on various components which help construct science identities such as their STE (science, technology, and engineering aspirations), the perception of science and scientists, teacher expectations and self-beliefs, peer attitude towards science, the perception of role models and parental attitude towards science.

5. ANALYSIS:

The responses of students obtained were used primarily to identify and categorize the students into high, low and average categories of science identity. Descriptive analyses and comparison of mean scores (t-tests) were used to obtain an overview of data and establish differences between urban and rural population. Next, the correlation was used to investigate the relationship between different components (perception of science and scientists, teacher expectations, STE aspirations etc) with science identity of students. Further, regression analyses was used to identify components which account for significant variance in outcome variable of science identity.

6. FINDINGS:

SCIENCE IDENTITY

The primary research question of the current study was concerned with science identity and factors affecting student's ability to recognize themselves with science. In order to address the first question the student's scores obtained through science identity questionnaire were classified into high, low and average categories. A frequency distribution shows that 16.29% of individuals fall within the low group of science identity. 77.77% represent average science identity and only 5.92 % reflect higher science identity. Urban and rural differences were obtained for which 10.52% of urban students depicted higher science identity as compared to 6.7% for the rural students.

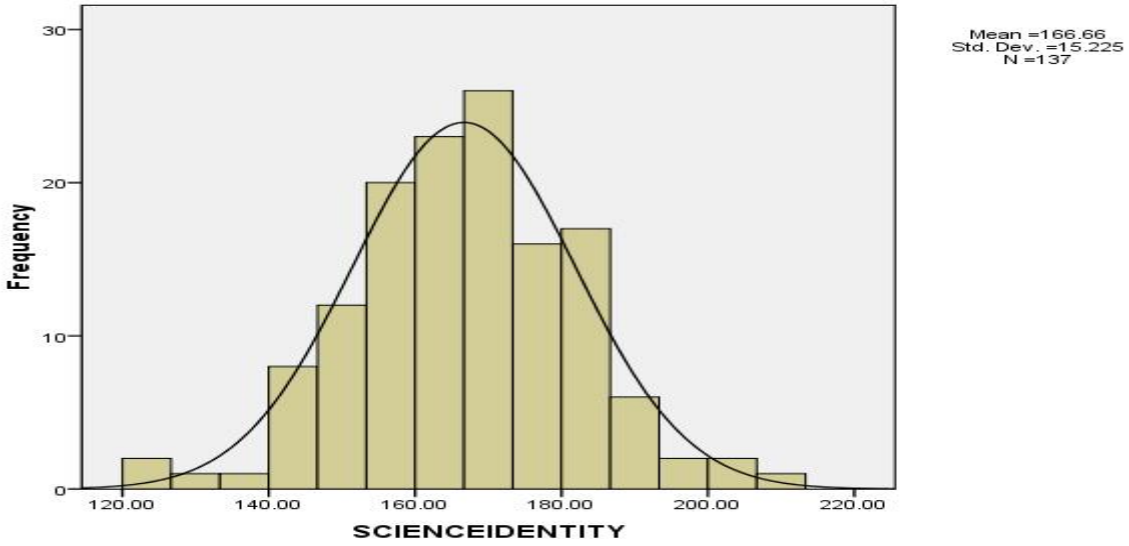

Fig. 1 Graph depicting scores obtained for Science Identity among students.

7. CORRELATIONAL ANALYSIS:

Variable	Coefficient of correlation (r)
Perception of science and scientists	0.542
Teacher expectation and self-beliefs	0.703
STE aspirations	0.477
Parental attitude towards science	0.499
Peer attitude towards science	0.430
Perception of role models	0.080

Table 1: An overview of the correlational analysis

Perception of science and scientists

Overall the students showed a favorable perception towards science and scientists with 67.4% falling under the higher category of scores. For the statement "Science is interesting" 92.7% of students agreed positively (Urban = 91.66%, Rural= 93.5%), but when asked "I think I could be a good scientist one day" only 57. 66% (Urban = 28.35%, Rural = 59.74%) complied with it, showing rural students have better recognition of them to be a scientist. The negative opinion towards scientists was depicted by the statement "Scientists can't be religious" wherein 57. 66 % (Urban= 53.33%, Rural = 61.03%) agreed to this view. The coefficient of correlation r= .542 was obtained with science identity of students. On comparison of rural and urban students, rural students depicted higher perception of

science and scientists (M= 34.16, SE= .60) than urban students (M= 32.26, SE =.78). This difference was not significant (135) = -1.84, p>0.5.

Teacher expectation and self-beliefs

Teacher expectations and self-beliefs were aligned mainly to the average category (60%). For statements like "My teacher cares if I think science is interesting" a total of 85.40% (Urban = 96.66%, Rural = 76.62%) agreed favorably, which shows teachers make an effort to make science interesting more in urban than rural areas. Similarly when asked if their teachers had high expectations of them a total of 67.53% confirmed it, in which again the rural students showed lesser scores. Thus, confiding implementation of more rigour among rural teachers. The coefficient of correlation r = .703(significant at .01 level) was obtained, and T values on a comparison of urban and rural students were not significant.

STE aspirations

Representation of students for science, technology,and engineering aspirations lied predominantly in the average category (62.96%) showing that lesser number of individuals are willing to uptake a career in science, this percentage was more for rural students as compared to urban. Percentage of students belonging to the higher category of STEM aspirations was 25.18% which was again higher for rural students as compared to urban students. The coefficient of correlation r = 0.477, was obtained with science identity. In order to compare means (M urban=11.93, M rural = 12.9) t values were obtained, which were not significant (-1.328) aligning towards no difference between urban and rural students.

Parental attitude towards science

Parent's attitude towards science was largely skewed towards positive direction (45.86 %) lied in the higher category, suggesting that students mostly perceive their parents to have a positive attitude towards science. When asked "My family would be happy if I decided to pursue career in science" 77.37% (Urban = 76.66%, Rural = 77.92%) agreed positively, but their opinions on families interest in science showed lesser favorability of 56.93% (Urban = 53.33%, Rural = 59.74%).The correlation between science identity and parental attitude was obtained to be r = 0.499 significant at .01 level of significance. Comparison of urban and rural scores, did not reveal significant values (M urban= 34.38, M rural = 35.09), t value (-1.061).

Peer attitude towards science

This variable assesses the influence of peers in the formulation of science identity among students. The distribution of scores is positively skewed with 39.25 % of students showing the favorable attitude of peers towards science. 33.57% (Urban= 41.6%. Rural = 27.27%) responded positively when asked if peers, "would think less of you if you did science activities". Thus, a large number is indicating towards a negative attitude of peers towards science. Urban students are more influenced by opinions of their peers as compared to rural students. The coefficient of correlation obtained was r = .430. On comparison of means (M urban= 12.26, M rural= 11.80), no significant difference was found t = .809.

Perception of Role models

This variable deals with how students perceive the status of their role model's in science for their own country. Overall student's depicted a less favorable perception of role models in science. 22.79% were categorized under favorable perceptions and 51.47% showed the moderate perception of role models. When asked "People who are the same gender as I am have trouble getting jobs in science in this country" 51.82% (Urban = 51.66 %, Rural = 51.94%) agreed positively, which indicates that students feel taking up a career in science does not provide with bright employment opportunities. The coefficient of correlation r = .080, showing the poor relationship between perception of role models and science identity. On comparison of means (M urban = 10.55, M rural= 10.67) between urban and rural students no significant differences(t = -.326) were obtained, p > .05.

8. REGRESSION ANALYSIS:

Regression analysis predicted that the aforementioned variables are strongest predictors of science identity. All the six predictors were significant at $p < .05$ level and R^2 obtained was .789, which means that regression model accounts for 78.9% variance in science identity of the students. These predictors contributed significantly towards science identity as summarized in the table:

Variables	β coefficient
Perception of science and scientists	0.309
Teacher expectations and self-beliefs	0.236
STEM aspirations	0.369
Parental attitude towards science	0.343
Peer attitude towards science	0.299
Perception of role models	0.136

Table 2 showing results of regression analysis

9. DISCUSSION OF RESULTS:

Science identity is a social construct wherein perception of various social elements which a child has access to, influence his opinions about day to day life. This study highlights this aspect wherein six primary factors have been identified which play an important role in the formulation of science identity. A very few students identified (5.92%) had strong science beliefs and recognized themselves with it, the majority(77.77%) were classified under those who value doing/ learning science but do not identify with it and 16. 3 % strictly did not identify themselves with science. It was also found that more number of urban students possessed higher science identity as compared to their rural counterparts, the reason for the same can be contemplated from the fact that rural students presented lower teacher expectation and self-beliefs, which can be key component in defining identity of learners in a rural environment (Gilbert & Yerrick, 2001).The reasons or factors responsible for influencing such perceptions among students were identified as six variables, for which aspirations in STEM aspirations has been found to be the strongest predictor followed by parents attitude towards science and attitude towards science and scientists. Career choices of students have been known to influence self-perceptions(Aschbacher, Li,and Roth, 2010), as students create an image of how good they will in doing science which reflects upon their decision to pursue it further (Archer et al, 2012).Previous researchers (Bennett & Hogarth, 2009; Brown, 2006) have also reflected upon that the image of scientists and appreciation of science regulates their identity with science. Parents largely influence the decision making of students for career choices which often translates into affinity of a child for a given field. Especially in an Indian context, it has been found that family influences are major contributing factors in determining career decision making of Indian students (Fouad et al, 2016), thus act as a key influence in determining science identity of students.

Peer attitude towards science is also one of the important contributors as according to Carlone's model recognizing by oneself and other's as a science person is significant for science identity formation. Since peers play an important role in identity formation, a negative attitude of peers towards science can hamper science identity of students. In addition, teachers are the most significant others in a student's life (Russell and Atwater's (2005) and Brown's (2002) and their belief in their students can help provide a vision for future. Around 70% of the students in the current study had low to average scores for teacher expectations which shows lower self-worth of students due to lack of teacher motivation and efforts. Therefore, it is important for the teacher to show trust and interest towards students in order to develop strong self-perceptions.

STE aspirations also show a pattern wherein lesser number of individuals is positively skewed, aspirations and identity is a paradox in which both are codependent and highly interrelated. Various studies Lindahl(2007)and Tai, Liu, Maltese &Fan (2006) showed that career interest in science is formed mainly in the age group of 13- 14 years. Therefore, in order to cultivate and develop students science aspirations, their engagement with identity work has to be realized (Archer et al, 2012).(Karunanayake and Nauta, 2004; Buxton and Lee, 2010) have suggested that underrepresentation in the STEM can be due lack of gender or race identified role models.This is also evident in the current study wherein the data supports a gap in students identification with role models, which can help them have a better perception of themselves as a science person in future.The study does not report significant differences between the urban and rural population in terms of six variables studied, the reason can be contemplated to the fact that although locale or situation of schools was different other demographics such as socioeconomic status, parental education) remain more or less the same.

10. CONCLUSION:

Various studies in science education stimulate the importance of the development of knowledge and skills with help of different teaching-learning methodologies. But here it is important to realize that nurturing short-term interest and knowledge cannot always help sustain student's long-term participation in science. Hence, it is important to recognize pertinent conditions or factors that help generate higher and persistent participation in science / STEM. This study thus helps present with factors with which students form substantial identities, which favors their development and contribution as responsible citizens of society.

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